NUMERICAL ANALYSIS OF BLAST PRESSURE PARAMETERS ON RC WALL WITH CIRCLE OPENING

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the
B. Eng (Hons.) in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2019

ACKNOWLEDGEMENTS

In the name of Allah, the utmost grateful to Allah for His permission, that this thesis was successfully finished. Alhamdulliah, first and foremost, I would particularly like to express my deepest gratitude to Allah SWT for the guidance and help in giving me the strength to complete this dissertation.

I would like to thank you my family who have supported me while I have been completing my research in terms of moral and finance. Especially my parents, Zaidi bin Jusoh and Rosmah binti Hasan, who always give me a motivation and inspiration during my study and to my partner Muhammad Taufik bin Suhaimi who have always convinced me to complete my research.

In addition, I would like to express my sincere gratitude to my supervisor, Dr. Mazlan bin Abu Seman for the continuous support of my research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I am very fortunate to have benefited from the convergence of each of his unique expertise. The best parts of this thesis would not have been possible without his inputs.

And last, but not least, also the moral support of relatives and friends is important. However, I would like to particularly mention my research partner, Muhammad Taufik bin Suhaimi and my buddies Ahmad Ridhwan, Mohd Zarif, Ahmad Fathiey and Muhammad Nur Aiman who have provided extraordinary moral support to ease my countless episodes of sufferings throughput the process.

ABSTRAK

Dinding konkrit bertetulang dikenali sebagai dinding penghalang yang digunakan untuk melindungi bangunan atau kawasan dari beban letupan. Dinding konkrit bertetulang adalah jenis yang digunakan untuk perlindungan. Kajian lanjut diperlukan untuk menyiasat letupan beban tekanan lampau kerana letupan dengan berat badan setara 13.61 kg (30 paun) TNT di kawasan medan letupan. Kerja sekarang bertujuan untuk menentukan kesan pada ubahan tekanan letupan disebabkan oleh dinding konkrit bertetulang dan dinding konkrit bertetulang dengan pembukaan bulatan jarak jarak jauh 1219 mm dari pusat berat caj sebagai jisim Trinitrotoluene (TNT) bersamaan dengan menggunakan perisian Analysis Unsur Terhingga, AUTODYN. Dinding konkrit bertetulang mempunyai dimensi keratan rentas 1829 mm x 1219 mm dengan ketebalan dinding 152 mm dan tebal 305 mm tapak kaki. Analisis letupan beban tekanan lampau dibahagikan kepada empat bahagian. Bahagian pertama menunjukkan analisis beban tekanan lampau ledakan berat 13.61 kg (30 paun) TNT dengan berat caj di tempat berlokasi 5486 mm (18 kaki) di ruang bebas. Berat caj terletak pada jarak 1219 mm (4 kaki) dari pusat dinding konkrit bertetulang. Kajian ini membandingkan ubahan beban tekanan lampau seperti yang dilaporkan oleh Yan et al. (2011) daripada ubahan letupan beban tekanan lampau. Bahagian kedua membentangkan analisis beban tekanan lampau ledakan 13.61 kg (30 paun) berat caj TNT yang terletak pada 1219 mm (4 kaki) dari dinding konkrit bertetulang. Tolok tekanan terletak pada 1219 mm (4 kaki), 2438 mm (8 kaki.), 3657 mm (12 kaki.), 4876 mm (16 kaki.) dan 5486 mm (18 kaki) . Bahagian ketiga menunjukkan analisis beban tekanan lampau ledakan 13.61 kg (30 paun) TNT berat yang terletak pada jarak 1219 mm (4 kaki) dari dinding konkrit bertetulang dengan 25% pembukaan bulatan manakala bahagian keempat juga sama dengan bahagian ketiga tetapi digantikan dengan dinding konkrit bertetulang dengan 50% pembukaan bulatan. Tolok tekanan berdasarkan bahagian kedua dan ketiga terletak sama berdasarkan lokasi tolok tekanan dari bahagian kedua. Dari hasil analisis letupan beban tekanan lampau, tekanan beban tekanan lampau antara dinding konkrit bertetulang (Jenis 2), dinding konkrit bertetulang dengan 25% pembukaan bulatan (Jenis 3) dan dinding konkrit bertetulang dengan 50% pembukaan bulatan (Jenis 4) adalah sama dalam jangka masa ubahan tekanan letupan. Ia adalah kerana jenis dinding konkrit bertetulang mempunyai kriteria dan sifat yang sama. Oleh itu, dinding konkrit bertetulang adalah mungkin untuk menggantikan dengan dinding konkrit bertetulang dengan pembukaan bulatan (25% atau 50%) kerana ia dapat menjimatkan kos peratusan konkrit tetapi tetap sama dalam jangka masa ubahan tekanan letupan. Dinding konkrit bertetulang dengan pembukaan bulatan memberikan lebih banyak nilai estetik dan ekonomik untuk menjadi perlindungan dalam jangka masa ubahan tekanan letupan. Dinding konkrit bertetulang juga mungkin menggunakan bentuk pembukaan lain seperti segi empat tepat, segi empat, segi tiga dan lain-lain yang akan memberi lebih berkesan dalam jangka masa ubahan tekanan letupan. Peratusan pembukaan yang digunakan untuk penyelidikan ini ialah 25% dan 50% pembukaan bulatan. Oleh itu, untuk penyelidikan seterusnya ia boleh mencadangkan dengan 30% atau 60% pembukaan bulatan untuk mendapatkan analisi yang lebih cekap berdasarkan letupan beban tekanan lampau.

ABSTRACT

Reinforced concrete (RC) wall is known as barrier wall used to protect of buildings or areas from blast loads. RC wall is the type used for protection. Further study is needed to investigate blast overpressure due to the explosive with 13.61 kg (30 lbs.) TNT equivalent weight in blast field area. Present work aim to determine the effect on the blast pressure parameters due to the solid RC wall and solid RC wall with circle opening at 1219 mm standoff distance from the centre of the charge weight as an equivalent mass of Trinitrotoluene (TNT) by using Finite Element (FE) software, AUTODYN. The RC wall has a cross-sectional dimension of 1829 mm x 1219 mm with wall thickness of 152 mm and 305 mm thickness of strip footing. The blast overpressure analysis divided to four parts. The first part present the blast overpressure analysis of 13.61 kg (30 lbs.) TNT charge weight at located 5486 mm (18 ft.) away on the free-field space. The charge weight are located at 1219 mm (4 ft.) away from the centre of the RC solid wall. This research compared the blast overpressure parameters as reported by Yan et al. (2011) of the blast overpressure parameters. The second part present the blast overpressure analysis of 13.61 kg (30 lbs.) TNT charge weight located at 1219 mm (4 ft.) away from the RC solid wall. The pressure gauge are located at 1219 mm (4 ft.), 2438 mm (8 ft.), 3657 mm (12 ft.), 4876 mm (16 ft.) and 5486 mm (18 ft.) away from the charge weight. The third part shows the blast overpressure analysis of 13.61 kg (30 lbs.) TNT charge weight at located at 1219 mm (4 ft.) away from the RC wall with 25% of circle opening while fourth part also similar to the third part but replaced with RC solid wall with 50% of circle opening. The pressure gauge based on second and third part are located similarly based on the location of pressure gauge from second part. From the result of the blast overpressure analysis, the blast overpressure between RC solid wall (Type 2), RC solid wall with 25% of circle opening (Type 3) and RC solid wall with 50% of circle opening (Type 4) are similarly in the term of blast pressure parameters. It is because of the type of the RC wall have similar criteria and properties of the designation. Therefore, the RC solid wall are possible to replace with RC solid wall with circle opening (25% or 50%) because it can save the cost of the percentage of concrete but still with same in the term of blast pressure parameters. RC wall with circle opening give more aesthetic value and economical to be as protection in the term of blast pressure parameters. RC wall also possible to use another shape of opening such as rectangle, square, triangle and others that will give more effective in the term of blast pressure parameters. The percentage of opening that used for this research are 25% and 50% of circle opening. So, for next research it can suggested with 30% or 60% of circle opening to get more efficiently based on the blast overpressure analysis.

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LIST OF SYMBOLS

kg	Kilogram
lbs	Pound
mm	Millimetre
ft	Foot
m	Metre
Pa	Pascal
ton	Tonne
cm	Centimetre
γ	Gamma
α	Alpha
ω	Omega
M	Mega
G	Giga

LIST OF ABBREVIATIONS

RC	Reinforced Concrete
TNT	Trinitrotoluene
UFC	Unified Facilities Criteria
DOD	Department of Defense
ALE	Arbitrary Lagrange Euler
RHT	Riedel, Hiermayer and Thoma
JC	Johnson and Cook
JWL	Jones-Wilkins-Lee
EOS	Equation of State
FE	Finite Element
HOB	Height of Burst
2D	2 Dimension
3D	3 Dimension

CHAPTER 1

INTRODUCTION

1.1 Research Background

Concrete is widely used in construction as well as protective structure, due to its good energy absorbing characteristic under high pressures. Concrete has also been used in many constructions as walls because of the high quality, speedy construction, cost of construction and energy efficiency. In designing of the protective structures, it is important to follow the proper design standards or guidelines and also to identify the possible threats and their risk of occurrence to enable the characteristic of the design loads. The reinforced concrete (RC) wall used to protect buildings or areas from blast damage, highly combustible or explosive materials when exposed to the explosions. RC wall is the type used for wall protection. Figure 1.1 shows RC wall that used as the protection.

Figure 1.1 Typical RC wall

For example, the Oklahoma City Bombing was an assault that involved the bombing on the Alfred P.Murrah Federal Building on April 19, 1995. The blast damaged

324 buildings within 16 blocks and shattered glasses in and around 258 nearby buildings, causing at least an estimated, loss of $652 million worth of damage. Figure 1.2 shows that the similar terrorist attack occurred in Bali bombing that happened on 12 October 2002 in the tourist region of Kuta on the Indonesian island of Bali. This terrorist attack led to improvements in engineering, especially in civil construction technology. This has allowed buildings to withstand greater forces, in which enhancements were incorporated into the design of new strong buildings.

Figure 1.2 Terrorist bombing attack in Bali

1.2 Problem Statement

In construction industry, blast impact study is very challenging due to the limitation to civilian and cost. The cost is very high due to the difficulty of the construction to build the building to resist blast load. Small RC panel subjected to blast load preferred in the experimental. Some researcher conduct blast test by validated 3D numerical modelling simulation. The result of the blast overpressure will approximately similar by validated numerical modelling vs experimental. This behaviour is similar to the numerical modelling research works conducted by Yan et al., (2011) and Seman, M. A. et al., (2019) where the simulated peak overpressure is close enough to the recorded blast overpressure, 490 kPa at 4.64 msec and 494.46 kPa at 4.62 msec, respectively.

Thus, insufficient study carried out for the RC wall subjected to blast load because of the limited access for civilian to conduct actual blast test. Nowadays, construction of the structures are not designed to resist blast load and not enough knowledge or fact about the impact of the blast load if hit the structure and object nearby of it. The blast loading of structures behind a barrier wall (Zhou and Hou, 2006), study the empirical results of pressures on a rigid wall behind a barrier to predict peak reflected pressure and impulse. The studies based on barrier wall research that determine pressures on structures behind a blast wall. The barrier wall's effect on a blast wave without the interference of structures or how blast waves are affected by a barrier to cause loads on structures behind the barrier.

1.3 Objective of the Research

The aim of this research is to investigate experimentally and numerically the behaviour of RC wall subjected to blast overpressure loading. To achieve this aim, specific objectives of the present work are set as follow:

1. The blast over pressure parameters of 13.61 kg (30 lbs.) TNT.

2. To study the blast overpressure parameters due to RC wall with and without circle opening.

1.4 Scope of the Research

In order to establish the mentioned objectives of the present research, the scope of this research can be explained as follows:

1. The numerical modelling of 13.61 kg (30 lbs.) TNT in AUTODYN 3D Finite Element. The simulation of the result will be verified by blast overpressure from Yan et al. (2011).

2. The subsequent of the numerical investigation is based on the three sequence of the study, blast on solid RC wall, blast on RC wall with 25% of circle opening and blast on RC wall with 50% of circle opening.

3. The RC wall with circle opening subjected to blast load of 13.61 kg (30lbs.) TNT equivalent weight at 1219 mm away from wall of the centre (Yan et al., 2011) is considered by using numerical simulation, AUTODYN. The dimension of the RC wall is 1829 mm tall, 1219 mm

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